Bulk power facilities SW Ontario

Supplementary
Information
February 1979

"BULK POWER FACILITIES - SW ONTARIO
SUPPLEMENTARY INFORMATION FEBRUARY 1979"

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BULK POWER FACILITIES - SOUTHWESTERN ONTARIO
SUPPLEMENTARY INFORMATION

INTRODUCTION

In December 1978, Ontario Hydro forwarded a submission entitled "Requirement for Additional Bulk Power Facilities in Southwestern Ontario" to the Royal Commission on Electric Power Planning. The Commission, in conducting an initial review of the submission, concluded that additional clarifying information would be useful, particularly as many readers would not have ready access to the evidence previously given by Ontario Hydro to the Commission. This document has been prepared to answer certain questions addressed to Ontario Hydro by the Commission in connection with the upcoming Southwestern Ontario hearings. It is hoped that the answers will assist in understanding Ontario Hydro's approach in assessing future load growth, some of the technical information and references in the submission, and the factors affecting the capability of the power system to supply load.

As outlined in the Commission's terms of reference, the regional hearings in Southwestern Ontario will deal with:

1. The electrical load growth in Southwestern Ontario to 1987 and from 1987 to year 2,000;

2. the capability of existing and committed bulk power generating and transmission facilities to supply this load, taking into account government policy with respect to use of interconnections with neighbouring utilities; and

3. the resulting date at which additional facilities if any, will be needed.

The Commission is not required to report on the specific nature of any additional bulk power facilities that may be required, nor the location and environmental aspects of such facilities, and has indicated that it will not hear submissions on those topics. In the event that the Commission finds that additional facilities will be needed, these aspects would be reviewed at a subsequent date in accordance with the Environmental Assessment Act.

Line Number

Question: Does Ontario Hydro's load forecasting process use estimates of various factors such as population growth rates, growth in households (including type of housing and heating), commercial manufacturing and industrial growth and the related uses of electricity, and technological change in the use of electricity in order to forecast electrical growth? If so, could such estimates be provided.

Answer: Estimates of such factors, and their relationship to electrical growth, represent the type of information which is useful when an end-use or explanatory approach is being used in forecasting. This has not been the approach taken by Ontario Hydro, with the result that the data gathered for Ontario Hydro's load forecasting is not of this type and has not been organized in this way.

However, the load forecasting methodology used by Ontario Hydro does rely heavily on estimates of local load growth provided by Hydro's wholesale customers (the municipal utilities), by direct industrial customers and by Ontario Hydro's regional offices (for retail areas serviced directly by Ontario Hydro). Embedded in these estimates are judgements based on first hand knowledge of the demand for electricity and local activites, factors or trends which will change these demands. During its participation in the regional hearings, it is intended that Ontario Hydro's regional personnel will be presenting, for discussion with the Commission, the local information which appears most pertinent to load growth in certain key areas in Southwestern Ontario.

The load growth estimates prepared at the local level are examined by the Regional Office staff for consistency and accuracy and any apparent anomalies are reviewed with the reporting agency. The estimates are then aggregated and the totals are examined

by head office staff for consistency, including consistency with general economic conditions. Also at this point computer calculations are done to produce a system forecast which is used for comparative purposes. The computer models used for these calculations assist in assessing the varying influences of alternative assumptions regarding economic indicators (including employment, productivity and income), demographic indicators, and certain other indicators. From these studies a range of projections is developed and a resultant most probable forecast is established, which has taken into account both local considerations and more general economic factors.

For instance, although recent trends in conservation and other customer actions tend to be reflected in the returns from the local areas and direct customers, an attempt is made to capture longer term gains in conservation, load management and improved end use efficiency predictions in the overall total aggregated forecast.

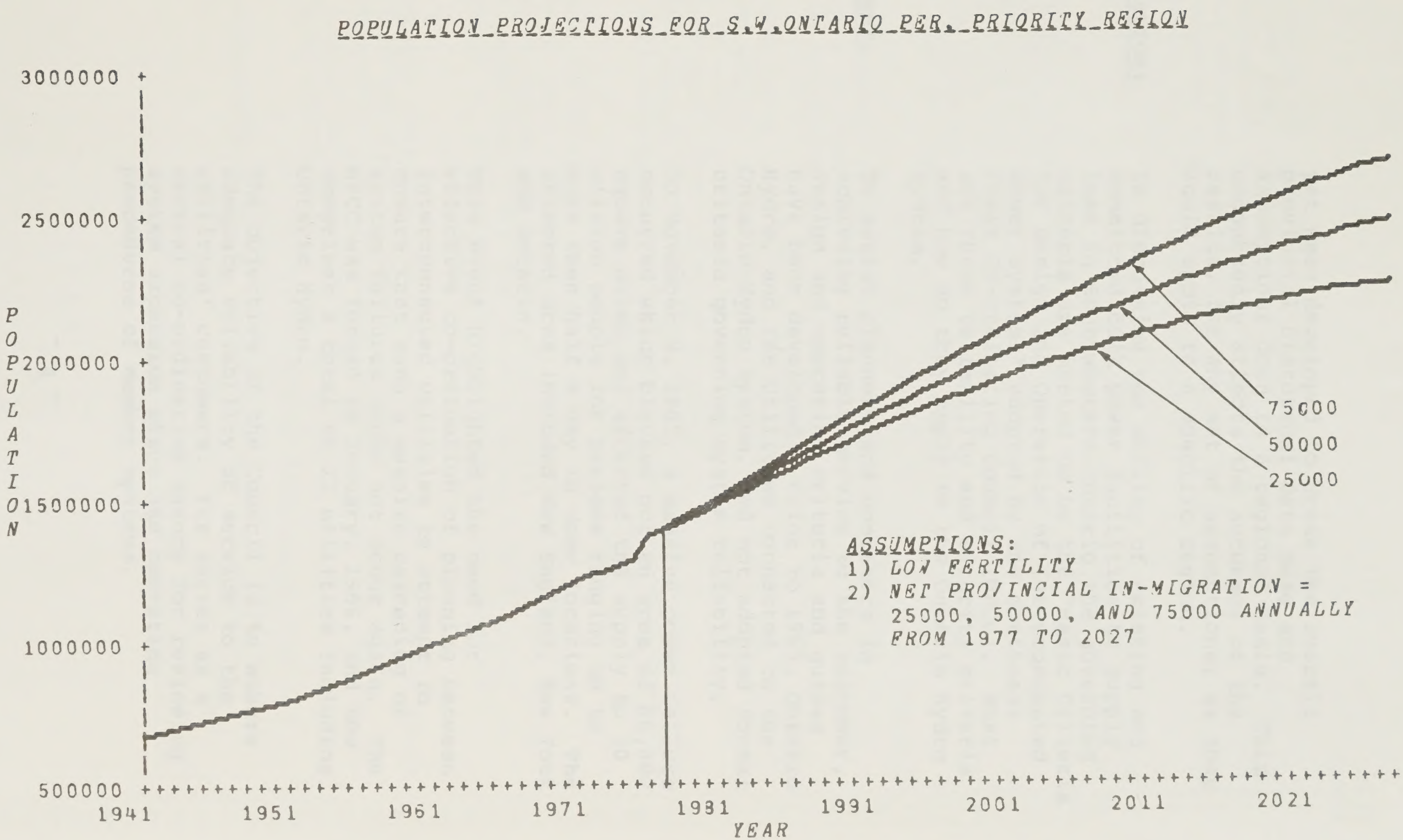
Some of the data utilized in the load forecasting process is developed within Ontario Hydro, in conjunction with other government agencies where appropriate. For the socio-economic data useful in determining overall provincial and regional trends Ontario Hydro relies mainly on information published by the provincial and federal government agencies. Examples are the annual publication of Ontario Statistics, the Annual Census of Manufacturing (derived from the Statistics Canada Survey) and population projections (prepared by TEIGA), all provided by the provincial government. Use is also made of Statistics Canada's "CANSIM" data base for historical time series disaggregation by regions and other characteristics. Additional information is also used such as the Canadata Construction File.

A copy of the most recent populations projections for the study area broken down by age group, sex and county has been provided to the Commission. This was prepared by Ontario Hydro from information developed by the Ministry of Treasury, Economics and Intergovernmental Affairs based on the 1976 mid-decennial survey. The graph opposite shows the total population forecast assuming low fertility rate and varying net migration into the province.

As previously indicated, estimates of factors which are useful in an end use approach to forecasting, similar to those mentioned in the Commission's question are not developed and used in the current forecast methodology. They are, however, developed by the CEA-SRI model discussed in the submission.

The complete set of historical data and the resultant forecasts for base scenario (Scenario 1) identified in the main submission is provided in Appendix A. This includes information on population, employment, number of households, both historical and predicted, as well as the related electrical energy growth. It must be emphasized that little experience has been gained to date with this model and the three scenarios in the submission indicate the effects of changing only a single input variable, the Ontario Gross Domestic Provincial Product. Until an understanding of the limitations, strengths and weaknesses of the model have been developed it will not be heavily relied upon in arriving at an official load forecast and the range of uncertainty associated with such forecast. It is however a useful analytic tool when comparing the effects on load growth in various energy sectors of a variety of postulated conditions.

At this stage in the development of the use of this model only limited capability has as


POPULATION PROJECTIONS FOR S.W.ONTARIO PER. PRIORITY REGION
3000000
2500000
2000000
1500000
1000000
500000
POPULATION
1941
1951
1961
1971
1981
1991
2001
2011
2021
YEAR
75000
50000
25000
ASSUMPTIONS:
1) LOW FERTILITY
2) NET PROVINCIAL IN-MIGRATION = 25000, 50000, AND 75000 ANNUALLY FROM 1977 TO 2027

yet been developed to break the overall provincial historical data base and assumptions down to a regional basis. This undoubtedly affects the accuracy of the results, for any set of assumptions, as they would apply to a specific region.

Question: In discussing the ability of existing and committed bulk power facilities to supply load in Southwestern Ontario the governing criteria are stated to be the "Basic Criteria for Design and Operation of Interconnected Power Systems" adopted by the Northeast Power Co-ordinating Council (NPCC). What are these reliability and security criteria and how do they apply to the Ontario Hydro system.

Answer: To assist planners and operators in achieving reliable service to the customer, design and operating criteria and guides have been developed. Prior to 1965, Ontario Hydro, and the Utilities connected to the Ontario Hydro system, had not adopted formal criteria governing system reliability.

On November 9, 1965, a massive power failure occurred which blacked out an area of 80,000 square miles and affected the supply to 30 million people for periods ranging up to more than half a day in some locations. The affected area included New England, New York and Ontario.

This event highlighted the need for effective co-ordination of planning between interconnected utilities to attempt to ensure that such a massive cascading of system failures could not occur again. The NPCC was formed in January, 1966, and now comprises a total of 21 utilities including Ontario Hydro.

The objective of the Council is to assure adequate reliability of service to the utilities' customers. Its serves as a central co-ordinating agency for reviewing system expansion plans and operating procedures of member systems.

A number of criteria for the design, operation and maintenance have been developed and adopted by the member systems. These are detailed in a document entitled "Basic Criteria for Design and Operation of Interconnected Power Systems" attached as Appendix "B" to this submission. The Three key principles embodied in the criteria are:

1) There should be adequate transmission to ensure that, in the event of the failure of a system element such as a generator, a transmission circuit, a transformer or a circuit breaker, cascading outages or major power interruptions will not occur.

2) The system should be operated within limits so that the loss of a system element will not precipitate cascading outages.
3) Plans should be made to minimize the size and duration of outages resulting from either operating error or from the loss of multiple facilities such as a four-unit generating station, all circuits on a transmission line right-of or a major load.

The reliability of supply to an individual customer is dependent not only on the local distribution system but on the strength and capability of the whole bulk power supply system and the reliability of the various interconnected utilities.

Compliance with the criteria insures that adequate levels of reliability will be maintained throughout the interconnected systems, so that widespread outages due to failures of the bulk power system will be infrequent.

The application of these principles and

criteria requires careful attention in the design of the system and the elements of the system. In both the planning and operating phases a great deal of computer testing is done to determine safe operating limits for various system conditions.

It is neither feasible nor necessary to test all elements of the power system for all of the conditions outlined in the criteria. From experience and judgement, the more severe and reasonably probable load and generation conditions are identified. Mathematical models of the power system are then used to determine if the system performance is adequate under these conditions. If the system is found adequate for these more severe contingencies it should be adequate for most contingencies.

For supply to Southwestern Ontario, three critical system conditions were identified. These conditions reflect the intent of the NPCC basic criteria. The conditions are:

A. Loss of a 2 circuit line with all other circuits in service; one unit producing at full output at at Lambton GS; and zero net exchange of power with Michigan.

B. Loss of a 2 circuit line with one circuit already out of service; three units in producing at full output at Lambton GS; and zero net exchange of power with Michigan.

C. Loss of a single circuit with all other circuits in service; three units producing at full output at Lambton GS; and a 2000 MW sale to Michigan.

In Condition "A" it is assumed that all transmission circuits are initially in service and one of the four Lambton generators is in service. It is assumed that there are no sales taking place to the United Stated. Under these conditions, the

loss of a 2 circuit line would be a less severe contingency than with more of the Lambton generators in service. While more than one Lambton generator will be available for service there have been a number of times when problems with coal supply, fish in the water intake and unit problems have required a reduction in the power output of Lambton GS to the level of one unit or less. Since a two circuit outage can occur suddenly and without warning, the system should not be called upon to supply a load level in excess of that which it can supply after the two circuit loss.

In Condition "B", one transmission circuit is initially out of service, three out of the four Lambton units are in service and there are no sales to United States utilities.

In criterion "C", all transmission circuits are initially in service, three out of the four units are producing at full output at Lambton GS and there is a 2000 MW sale to Michigan. For this condition a less severe is considered warranted because there is no assurance there will be such sales and interruptible power sales to Michigan could be interrupted in the event of storm warnings or other evidence of an impending emergency.

Testing of the system model requires that the loading on all elements be examined to ensure that the capability of each element is not exceeded and that the system will be transiently stable, i.e., it will settle down to a new condition without initiating cascading outages.

It is possible that the system could be in a stable state and the loss of a system element would apparently result in another stable state in which load and system capability would be matched. It may not however be possible to make a transition from one state to the other state without other elements of the system being lost.

For instance, when Bruce B units start coming into service in 1982, and without the installation of additional transmission facilities, the capability of the system to supply load in Southwestern Ontario will be affected because the system would be transiently unstable for a number of possible faults. Such instablity could result in widespread blackouts in Ontario and in parts of the United States. To prevent this from occurring generators would be disconnected from the system (generation rejection) to reduce the power flow from Bruce and it would also be necessary to reject load from the system i.e. interrupt power to some customers. To be effective, the disconnection of the generators and interruption of the load must take place within a fraction of a second after the circuit is faulted.

As noted earlier, it is the intent of the NPCC criteria to prevent widespread power interruptions by ensuring there are adequate transmission and generation facilities. When the timely installation of requisite bulk power facilities is delayed for whatever reason, it becomes necessary to resort to measures which permit Ontario Hydro to live up to the intent of the criteria insofar as this is possible. Examples of these measures are: using generation rejection to increase operating limits; using of load rejection i.e. load is rapidly disconnected from the system when a transmission circuit or other element is faulted; and running uneconomic generation. For example, the output of Bruce GS could be limited and other more costly generation could be run to replace the Bruce output.

The criteria for the bulk power system are backed up by other criteria or design guidelines to ensure the adequacy of supply to local loads. One of these, entitled "Guides for Planning Area and Regional

Supply Facilities" was included as Appendix "10J" of the Ontario Hydro Memorandum to the Commission entitled "Reliability", dated May, 1976, (Exhibit 20-0). A copy of these guides is attached as Appendix "B" to this document. The intent of the guides is to minimise the frequency and duration of service interruptions.

These guides apply to subsystems and are consistent with the overall NPCC criteria, and recognize that the reliability of supply to an individual customer is dependent on both the local distribution system and strength and capability of the whole bulk power system and the reliability of the various interconnected utilities.

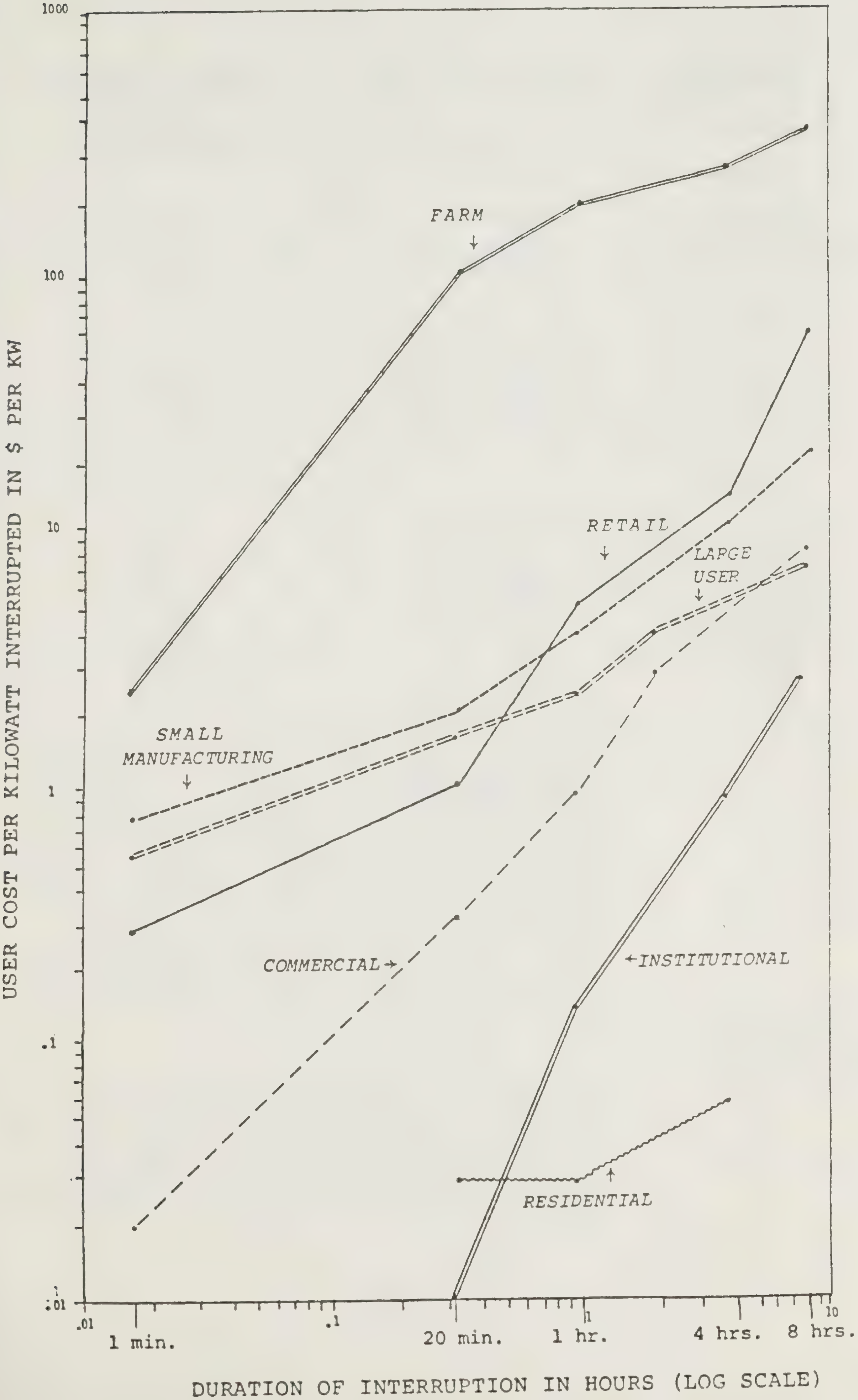
Question: What value do the customers place on reliability of service?

Answer: Ontario Hydro has recently undertaken a number of survey of customers attitudes to reliability of supply in various customer groups. Three reports namely those providing the response from large industrial customers, small industrial customers and farm customers, have been finalized and filed with the Commission and reports dealing with responses from commercial, institutional and residential customers are being prepared. The average value which the various classes of customers place on an interruption in their supply is shown in the figure opposite. It will be seen that the farm group placed the highest value on reliability of service, followed by small industry, large industry, commercial group, institutions and finally residential customers.

Question: What are the "existing and committed bulk power generation facilities" and what is their role in meeting load?

Answer: The existing and committee bulk power genertating facilities at the boundary of or within the study area includes.

USER ESTIMATES OF INTERRUPTION COSTS



Hydraulic	Installation Date	Nominal Capacity
Eugenia GS	1915 - 1920	3.5 MW
Nuclear		
Douglas Pt.	1967	206 MW
Bruce "A" GS	1976 - 1978	2960 MW
Bruce "B" GS	1982 - 1985	3024 MW
Coal		
J.C. Keith	1951 - 1953	254 MW
Lambton	1969 - 1970	1980 MW
Nanticoke	1972 - 1978	3920 MW
Oil Combustion Turbines		
Lambton GS	1967	22 MW
J.C. Keith GS	1967	7 MW
Sarnia Scott	1965 - 1966	71 MW
Detweiler	1967	75 MW
Bruce A	1974 - 1976	56 MW
Nanticoke	1971	22 MW
Bruce	1976	42 MW
Bruce B	1981 - 1983	56 MW

The load characteristics set the operating conditions which must be met by the various power resources on the system. In addition to following the instantaneous changes in demand the generating capacity must also be capable of meeting large variations in daily loads, reducing the energy production during the nighttime hours, and increasing it rapidly in the morning as load builds up. Apart from safety, the first consideration is to operate the system reliably, and the second consideration is to do this at lowest cost.

The reliability of the existing system is dependent on the operation of generation located in diverse geographic locations, and the scheduling of generation operating reserves which must be held in readiness to replace unforeseeable failure of generating units.

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Cost considerations lead to specific "stacking" or "merit" order loadings of generation. These are generally aimed at achieving least possible use of the more expensive fuels.

For example, available hydraulic energy is used first, then nuclear followed by coal and oil. (Gas is burned at the Hearn Plant in Toronto under existing contracts but it is planned to decrease gas usage). Energy produced by combustion turbine units is considerably more costly than energy produced by large units. Typical average running and operating costs per kilowatt-hour are hydraulic .1 cents, nuclear .2 cents, coal 1.5 cents, oil 2.5 cents, combustion turbines 5.0 cents.

Because of their energy production costs the nuclear units are designed to operate as continuously as possible. Coal-fired units are operated to meet irregular loads because of much higher fuelling cost. Combustion turbine units are used primarily to provide capacity for short periods during the winter peak.

If energy is locked in at a hydraulic or a nuclear plant the cost penalty can be very high. For example, at Bruce GS the need to replace nuclear energy with coal and oil energy resulted in a penalty of about 13 million dollars during 1978, even though it was possible to transmit most of the energy out of Bruce. The loss of the output of a 750 unit for 1 hour, assuming the energy is replaced by coal-fired capacity, would cost about $10,000.

<u>Question:</u> What are "existing and committed bulk power transmission facilities" in Southwestern Ontario and what are the "stop-gap measures" being taken to increase their capability to supply load in the area?

Line Number

Answer: The existing and committed bulk power transmission facilities in the study area are shown on Figure 2 of the main submission. Power from generating stations is generally transformed to a higher voltage for transmission to point of use, or load centres. Ontario Hydro's bulk power transmission lines operate at voltages of 500 kV (500,000 volts), 230 kV, or 115 kV. The bulk power transmission network is designed so that the generation at a number of diverse locations can be used to supply the main load.

Near the load centers, electricity is taken from the bulk power transmission network and stepped down through transformers to lower voltages for transmission to locations closer to the loads. Voltages may range from 230 kV to 27.6 kV.

For the bulk power system, it is the capability of the system to maintain an adequate supply of power to the major transformer stations which is most important for the critical load area in Southwestern Ontario. The forecast station loads are set out in Figure 6 of the main submission.

At the load centres, electricity is stepped down through transformers to lower voltages, for distribution to locations adjacent to ultimate customers. At these locations the voltage is stepped down further to deliver electricity to customers at the voltages they use. Small customers take electricity at 115 volts or 230 volts but large customers take electricity at higher voltages.

In Southwestern Ontario 230 kV is used as the bulk power transmission voltage. The critical facilities for the supply of Southwestern Ontario consist of the 230 kV lines interconnecting the Hamilton, Kitchener and London areas. These lines have been in-service for many years. They were originally installed to bring power

from the hydraulic generation at Niagara and in eastern and northern Ontario to the loads in southwestern Ontario. The construction of J. Clark Keith GS in the early 1950's and Lambton GS in the late 1960's reduced the westward power flow on the lines and at times reversed its direction. In more recent years the increasing load in southwestern Ontario has increased the westward flow in the more critical transmission lines and now require that measures be taken to increase the capacity of these lines.

These measures are called stop-gap measures because they are remedial measures only until new bulk power facilities can be placed in service.

Stop-gap measures to uprate transmission lines require some combination of the following:

- restringing a line with heavier conductors
- raising towers by adding extensions
- replacing angle and anchor towers with stronger towers on new foundations.

Stop-gap measures at major transformer and switching stations require the following type of work:

- replacing or uprating current carrying parts of station equipment such as circuit breaker, line disconnects, station buswork, etc.
- installing large banks of static capacitors.

The static capacitors are required to ensure acceptable system voltages required at the heavier loadings of the transmission system. If the capacitors were left in service at times when lines are lightly loaded (eg. at night), the system voltages would be too high. Therefore it is necessary to switch the capacitors on and off to match the loading on the transmission

lines. If a transmission circuit is faulted and switched out of service, then the loadings on the lines remaining in service are increased. If blackouts are to be avoided then the static capacitors must be switched on immediately by automatic controls. The automatic control schemes must be carefully designed to function correctly under all system conditions.

The stop-gap measures are complex, requiring many thousands of hours of engineering study and design which are still ongoing. Final estimates of the costs of stop-gap facilities are not yet available. However, preliminary estimates indicate that the total cost will be about $60,000,000. It is expected that the stop-gap measures will have limited value after the major bulk facilities are placed in service.

On page 15 of the document "Requirements for Additional Bulk Power Facilities in Southwestern Ontario" a summary was provided of the expected capacity improvements in the critical transmission lines as a result of these stop-gap measures.

<u>Question:</u> How are the capability of existing and committed bulk power facilities and the use of interconnections with neighbouring utilities related?

<u>Answer:</u> Ontario Hydro is interconnected with power systems in the Provinces of Manitoba and Quebec and the States of Michigan and New York. These interconnections affect the capability to supply load by providing improved reliability against operating problems which arew encountered on the system from time to time. In addition, they allow an interchange of power between systems whose heaviest loads may develop at different times of the year, and can reduce power and energy losses on the transmission system because of the additional transmission paths available for power flows.

Interconnections also permit economy sales between systems, allowing one system which may have surplus generation which can produce energy at a lower cost to sell such energy to a neighbouring system which would otherwise have to operate higher cost generating units or purchase higher cost energy elsewhere. Such sales from Ontario to the United States can be interrupted if emergencies arise requiring the power within Ontario. During 1976, 1977 and 1978 Hydro had earned more than $575 million in gross revenues from power exported to the U.S. This revenue has made a substantial reduction in the impact Ontario power consumers in the past couple of years. There may be greater opportunities for profitable sales in the future.

Power which is exported to or imported from other utilities must be considered when determining the required capability of transmission facilities. In the future, inadequate transmission facilities could eliminate the possibility of making profitable sales to the United States.

Also in April 1978, the Ontario Government, on being advised by Ontario Hydro of the potential for excess generating capacity on the Ontario Hydro system, requested that Ontario Hydro investigate opportunities for export of firm power to neighbouring utilities. The status of these studies was described in Ontario Hydro's submission to the Commission "Total Electric Power System" dated October 1978, a copy of which can be obtained either from the Commission or from Ontario Hydro.

Essentially the work of identifying potential sales is still ongoing but the possibilities of taking advantage of such sales would be limited by the strength of the bulk power transmission system and by the capacity of the interconnections.

Line Number

<u>Question</u>: Could you provide statistics on transmission line and switchgear failure in Southwestern Ontario?

<u>Answer</u>: The tables in Appendix "D" provide failure statistics for the 9 critical 230 kV circuits in Southwestern Ontario. The circuits are identified by their operating designation, eg. D4W. The stations at which these circuits generate and their geographical location can be seen by reference to figures 11 and 2 of the main submission.

The statistics provide the average annual frequency and duration of outages due to all causes except those scheduled for line work.

APPENDIX A

SOUTHWESTERN ONTARIO

S C E N A R I O 1

ELECTRIC ENERGY MARKETS

	HISTORY 1955	******** 1966	******** 1967	******** 1968	******** 1969	******** 1970	******** 1971	******** 1972	******** 1973	******** 1974	******** 1975	******** 1976
ELECTRIC ENERGY CONSUMPTION												
RESIDENTIAL (GWH)												
SPACE HEATING	118.	128.	179.	234.	288.	342.	401.	515.	642.	772.	912.	1055.
WATER HEATING	1094.	1130.	1136.	1150.	1194.	1230.	1237.	1240.	1252.	1255.	1321.	1343.
APPLIANCES ETC.	974.	1101.	1254.	1393.	1537.	1663.	1791.	1940.	2059.	2214.	2277.	2464.
TOTAL RESIDENTIAL ELECTRICITY	2186.	2359.	2569.	2782.	3019.	3235.	3429.	3695.	3953.	4241.	4490.	4862.
TOTAL FARM (GWH)	584.	615.	670.	709.	755.	811.	848.	874.	925.	972.	1016.	1074.
COMMERCIAL (GWH)												
HEATING	54.	63.	71.	78.	84.	96.	97.	107.	113.	114.	116.	118.
OTHER(MOTORS + LIGHTING)	888.	1028.	1157.	1273.	1362.	1556.	1569.	1732.	1834.	1843.	1886.	2028.
STREET LIGHTING	84.	89.	94.	101.	108.	113.	117.	123.	130.	136.	149.	153.
TOTAL COMMERCIAL ELECTRICITY	1026.	1180.	1322.	1452.	1554.	1765.	1783.	1962.	2077.	2093.	2151.	2304.
INDUSTRIAL												
MANUFACTURING (GWH)												
ALUMINUM												
PULP + PAPER -	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
CHEMICALS	793.	854.	851.	946.	926.	1003.	990.	1000.	1000.	1001.	1124.	1149.
STEEL	3.	4.	3.	3.	4.	4.	4.	8.	9.	10.	8.	9.
LIGHT MANUFACTURING	2569.	3171.	3529.	4050.	4454.	4969.	5505.	5798.	5891.	5927.	5966.	6446.
*OTHER HEAVY MANUFACTURING	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
SUBTOTAL-MANUFACTURING	3370.	4029.	4383.	4999.	5384.	5981.	6499.	5806.	6900.	6938.	7093.	7604.
MINING (GWH)												
IRON	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
COPPER	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
COAL												
OTHER	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
SUBTOTAL-MINING	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
TOTAL INDUSTRIAL ELECTRICITY	3370.	4029.	4383.	4999.	5384.	5931.	6499.	5835.	6900.	6938.	7098.	7604.
*TOTAL OTHER												
TOTAL CONSUMPTION (GWH)	7166.	8183.	8944.	9942.	10712.	11792.	12559.	13337.	13855.	14244.	14755.	15844.
LOSSES AND EXPORTS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
TOTAL DISPOSABLE ENERGY (GWH)	7165.	8183.	8944.	9942.	10712.	11792.	12559.	13337.	13855.	14244.	14755.	15844.

SOUTHWESTERN ONTARIO

S C E N A R I O 1

ELECTRIC ENERGY MARKETS

	FORECAST 1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1990	1995	2000	2005
ELECTRIC ENERGY CONSUMPTION														
RESIDENTIAL (GWH)														
SPACE HEATING	1235.	1404.	1564.	1714.	1858.	1995.	2125.	2250.	2370.	2485.	2907.	3427.	4013.	4674.
WATER HEATING	1382.	1416.	1448.	1479.	1508.	1536.	1564.	1591.	1619.	1645.	1749.	1864.	1985.	2113.
APPLIANCES ETC.	2589.	2705.	2823.	2946.	3073.	3206.	3345.	3490.	3641.	3799.	4454.	5165.	5936.	6937.
TOTAL RESIDENTIAL ELECTRICITY	5206.	5525.	5835.	6139.	6439.	6737.	7034.	7332.	7630.	7930.	9110.	10456.	11984.	13724.
TOTAL FARM (GWH)	1140.	1201.	1260.	1318.	1375.	1433.	1490.	1547.	1604.	1652.	1890.	2150.	2445.	2777.
COMMERCIAL (GWH)														
HEATING	247.	375.	503.	631.	762.	894.	1028.	1166.	1306.	1450.	2049.	2847.	3773.	4853.
OTHER(MOTORS + LIGHTING)	2155.	2287.	2427.	2575.	2732.	2898.	3075.	3262.	3461.	3658.	4488.	5467.	6658.	8103.
STREET LIGHTING	165.	172.	179.	187.	195.	203.	211.	220.	229.	239.	278.	323.	374.	434.
TOTAL COMMERCIAL ELECTRICITY	2567.	2834.	3109.	3393.	3688.	3995.	4314.	4648.	4996.	5346.	6815.	8537.	10804.	13394.
INDUSTRIAL														
MANUFACTURING (GWH)														
ALUMINUM														
PULP + PAPER	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
CHEMICALS	1195.	1242.	1292.	1343.	1397.	1452.	1510.	1570.	1633.	1693.	1965.	2277.	2637.	3055.
STEEL	9.	9.	10.	10.	10.	10.	11.	11.	11.	12.	13.	14.	15.	17.
LIGHT MANUFACTURING	6662.	6886.	7117.	7356.	7603.	7859.	8123.	8395.	8677.	8969.	10152.	11495.	13015.	14737.
*OTHER HEAVY MANUFACTURING	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
SUBTOTAL-MANUFACTURING	7866.	8138.	8419.	8710.	9010.	9321.	9643.	9976.	10321.	10678.	12130.	13786.	15668.	17809.
MINING (GWH)														
IRON	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
COPPER	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
COAL														
OTHER	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
SUBTOTAL-MINING	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
TOTAL INDUSTRIAL ELECTRICITY	7866.	8138.	8419.	8710.	9010.	9321.	9643.	9976.	10321.	10678.	12130.	13786.	15568.	17809.
*TOTAL OTHER														
TOTAL CONSUMPTION (GWH)	16779.	17698.	18622.	19559.	20512.	21486.	22482.	23502.	24551.	25615.	29344.	35029.	40931.	47785.
LOSSES AND EXPORTS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
TOTAL DISPOSABLE ENERGY (GWH)	16779.	17698.	18622.	19559.	20512.	21486.	22482.	23502.	24551.	25615.	29344.	35029.	40931.	47785.

SOUTHWESTERN ONTARIO

S C E N A R I O 1

COMPETITIVE ENERGY MARKETS AND PRICES

	HISTORY 1965	******** 1966	******** 1967	******** 1968	******** 1969	******** 1970	******** 1971	******** 1972	******** 1973	******** 1974	******** 1975	******** 1976
COMPETITIVE ENERGY MARKETS												
RESIDENTIAL												
SPACE HEATING-MARKET SHARES												
PCT HOUSEHOLDS-ELECTRIC	1.5	1.6	2.2	2.8	3.4	4.0	4.6	5.8	7.0	8.2	9.4	10.6
PCT HOUSEHOLDS-GAS	29.4	29.3	32.2	33.5	36.2	37.7	39.3	40.6	40.1	42.0	42.6	46.8
PCT HOUSEHOLDS-OIL	60.8	59.2	58.5	57.9	55.9	55.2	53.8	52.3	51.6	48.6	47.0	41.7
PCT HOUSEHOLDS-SOLIDS	8.3	9.9	7.1	5.8	4.5	3.1	2.3	1.3	1.3	1.2	1.0	0.9
TOTAL-PCT	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
TOTAL SPACE HEATING												
REQUIREMENTS-GWH EQUIVALENT	7867.	8000.	8136.	8357.	8471.	8550.	8717.	8879.	9171.	9415.	9702.	9952.
WATER HEATING-MARKET SHARES												
PCT HOUSEHOLDS-ELECTRIC	46.2	47.0	46.5	45.9	47.0	48.0	47.3	46.6	45.5	44.4	44.7	45.0
PCT HOUSEHOLDS-GAS	44.4	42.0	44.2	44.4	45.7	44.9	44.3	43.2	45.4	46.6	48.3	49.0
PCT HOUSEHOLDS-OIL	2.4	2.5	2.3	2.7	3.4	3.9	5.0	5.7	5.3	6.1	5.3	4.5
PCT HOUSEHOLDS-SOLIDS	7.0	8.5	7.0	7.0	3.9	3.2	3.4	4.5	3.8	2.9	1.7	1.5
TOTAL-PCT	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
TOTAL WATER HEATING												
REQUIREMENTS-GWH EQUIVALENT	2368.	2404.	2443.	2505.	2540.	2563.	2615.	2661.	2752.	2827.	2911.	2984.
COMMERCIAL												
HEATING-USEFUL ENERGY-PCT												
MARKET SHARE-ELECTRIC	1.0	1.1	1.2	1.3	1.3	1.4	1.4	1.5	1.5	1.5	1.5	1.5
MARKET SHARE-GAS	30.8	29.2	33.6	33.6	38.4	39.7	44.2	47.5	53.0	62.4	74.5	74.2
MARKET SHARE-OIL	56.3	61.0	57.8	59.4	55.6	55.6	52.4	49.5	45.0	35.7	24.0	24.3
MARKET SHARE-SOLIDS	11.9	8.7	7.4	5.7	4.7	3.3	2.0	1.5	0.5	0.4	0.0	0.0
TOTAL PCT	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
TOTAL COMMERCIAL HEATING												
REQUIREMENTS-GWH EQUIVALENT	5400.	5727.	5917.	6000.	6462.	6857.	6928.	7133.	7533.	7600.	7733.	7867.
NEW HOUSING-PCT ELECTRIC SPACE	14.8	22.3	16.8	13.2	16.8	18.0	24.2	25.1	24.5	24.0	25.7	30.1
ENERGY PRICES												
RESIDENTIAL RATES												
ELECTRICITY-C/KWH	1.30	1.29	1.29	1.33	1.38	1.43	1.50	1.54	1.65	1.76	1.96	2.24
ELECTRICITY-$/MIL BTU	3.80	3.80	3.80	3.90	4.00	4.20	4.40	4.50	4.80	5.20	5.70	6.55
GAS-$/MIL BTU	1.23	1.24	1.22	1.22	1.21	1.22	1.21	1.21	1.23	1.32	1.65	2.16
OIL-$/MIL BTU	1.09	1.09	1.13	1.19	1.22	1.26	1.32	1.38	1.55	1.95	2.22	2.61
COMMERCIAL RATES												
ELECTRICITY-C/KWH	1.36	1.32	1.31	1.33	1.33	1.34	1.40	1.44	1.34	1.45	1.60	1.85
ELECTRICITY-$/MIL BTU	3.93	3.87	3.84	3.90	3.90	3.93	4.10	4.22	3.92	4.24	4.69	5.42
GAS-$/MIL BTU	0.95	0.94	0.93	0.91	0.88	0.87	0.87	0.85	0.88	0.93	1.27	1.78
OIL-$/MIL BTU	0.79	0.79	0.83	0.89	0.92	0.96	1.02	1.03	1.26	1.65	1.92	2.31
INDUSTRIAL RATES												
ELECTRICITY-C/KWH	0.74	0.73	0.74	0.78	0.82	0.86	0.92	0.94	0.86	0.94	1.09	1.32

SOUTHWESTERN ONTARIO

SCENARIO 1

COMPETITIVE ENERGY MARKETS AND PRICES

	FORECAST 1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1990	1995	2000	2005
COMPETITIVE ENERGY MARKETS														
RESIDENTIAL														
SPACE HEATING-MARKET SHARES														
PCT HOUSEHOLDS-ELECTRIC	12.2	13.7	15.0	16.2	17.3	18.3	19.3	20.1	20.9	21.6	23.8	26.6	29.5	32.5
PCT HOUSEHOLDS-GAS														
PCT HOUSEHOLDS-OIL														
PCT HOUSEHOLDS-SOLIDS														
TOTAL-PCT														
TOTAL SPACE HEATING REQUIREMENTS-GWH EQUIVALENT	10114.	10264.	10413.	10564.	10718.	10875.	11035.	11198.	11363.	11531.	12190.	12881.	13615.	14395.
WATER HEATING-MARKET SHARES														
PCT HOUSEHOLDS-ELECTRIC	45.6	46.0	46.4	46.7	46.9	47.1	47.3	47.4	47.6	47.7	47.9	48.1	48.2	48.4
PCT HOUSEHOLDS-GAS														
PCT HOUSEHOLDS-OIL														
PCT HOUSEHOLDS-SOLIDS														
TOTAL-PCT														
TOTAL WATER HEATING REQUIREMENTS-GWH EQUIVALENT	3032.	3077.	3121.	3166.	3212.	3259.	3306.	3354.	3403.	3453.	3651.	3876.	4115.	4367.
COMMERCIAL														
HEATING-USEFUL ENERGY-PCT														
MARKET SHARE-ELECTRIC	3.1	4.6	6.0	7.4	8.7	10.0	11.1	12.3	13.4	14.4	18.1	22.2	25.9	29.3
MARKET SHARE-GAS														
MARKET SHARE-OIL														
MARKET SHARE-SOLIDS														
TOTAL PCT														
TOTAL COMMERCIAL HEATING REQUIREMENTS-GWH EQUIVALENT	7993.	8147.	8324.	8524.	8742.	8977.	9229.	9496.	9778.	10073.	11314.	12818.	14559.	16558.
NEW HOUSING-PCT ELECTRIC SPACE														
ENERGY PRICES														
RESIDENTIAL RATES														
ELECTRICITY-C/KWH	2.40	2.57	2.75	2.94	3.15	3.37	3.61	3.87	4.14	4.43	5.71	7.30	9.34	11.94
ELECTRICITY-$/MIL BTU	7.02	7.52	8.05	8.62	9.23	9.83	10.59	11.32	12.12	12.98	16.73	21.39	27.35	34.97
GAS-$/MIL BTU	2.34	2.53	2.73	2.95	3.19	3.45	3.73	4.03	4.36	4.72	6.32	8.49	11.41	15.32
OIL-$/MIL BTU	2.77	2.93	3.11	3.30	3.49	3.70	3.92	4.16	4.41	4.67	5.91	7.93	10.65	14.31
COMMERCIAL RATES														
ELECTRICITY-C/KWH	2.00	2.16	2.34	2.53	2.73	2.96	3.20	3.45	3.74	4.04	5.36	6.86	8.77	11.21
ELECTRICITY-$/MIL BTU	5.86	6.34	6.85	7.41	8.01	8.66	9.36	10.12	10.94	11.83	15.71	20.09	25.68	32.84
GAS-$/MIL BTU	1.94	2.12	2.32	2.53	2.76	3.01	3.29	3.59	3.92	4.28	5.91	7.94	10.67	14.34
OIL-$/MIL BTU	2.45	2.60	2.75	2.92	3.09	3.28	3.47	3.68	3.90	4.14	5.23	7.02	9.43	12.67
INDUSTRIAL RATES														
ELECTRICITY-C/KWH	1.43	1.54	1.67	1.80	1.95	2.11	2.28	2.46	2.67	2.86	3.83	4.89	6.26	8.03

SOUTHWESTERN ONTARIO

S C E N A R I O 1

MACRO ECONOMIC INDICATORS AND INDUSTRIAL OUTPUT

	HISTORY 1955	******** 1966	******** 1967	******** 1968	******** 1969	******** 1970	******** 1971	******** 1972	******** 1973	******** 1974	******** 1975	***** 1976
ECONOMIC INDICATORS												
GROSS DOMESTIC PROVINCIAL PRODUCT(MILLIONS OF 1976$)	8176.	8239.	9273.	9936.	10690.	10865.	11396.	12197.	12841.	13323.	13270.	14339.
GDPP-MANUFACTURING(MILS 1976$) "	2493.	2896.	2821.	3012.	3269.	3168.	3373.	3627.	3895.	4016.	3930.	4310.
GDPP-AGRICULTURE(MILS 1976$) "	188.	228.	196.	214.	226.	235.	233.	223.	187.	162.	199.	227.
POPULATION(THOUSANDS)	1407.	1464.	1492.	1527.	1570.	1585.	1611.	1653.	1659.	1714.	1755.	1781.
GDPP-$/CAPITA (1976$)	5811.	5628.	6215.	6507.	6809.	6855.	7074.	7379.	7694.	7773.	7566.	8051.
TOTAL EMPLOYMENT(THOUSANDS)	504.	536.	548.	561.	590.	589.	600.	625.	655.	690.	693.	717.
EMPLOYMENT-SERVICE SECTOR(000)	275.	294.	306.	321.	345.	352.	364.	385.	404.	430.	445.	452.
HOUSEHOLDS(THOUSANDS)	438.	445.	452.	464.	470.	475.	484.	493.	509.	523.	539.	553.
INDUSTRIAL PRODUCTION												
ALUMINUM (000 TONS)												
WOOD PULP (000 TONS)												
CHEMICALS (MILS $ OF SHIP)	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
STEEL (000 NET TONS)	95.8	102.5	102.1	113.5	117.6	122.0	130.6	140.6	160.0	236.0	292.2	298.7
	6.	8.	6.	6.	8.	8.	8.	16.	18.	20.	16.	18.
MINING												
IRON ORE (000 TONS)	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
COPPER (000 TONS)	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
COAL (000 TONS)												
OTHER (000 TONS)	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
TOTAL MINING ACTIVITY-000 TONS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

SOUTHWESTERN ONTARIO

S C E N A R I O 1

MACRO ECONOMIC INDICATORS AND INDUSTRIAL OUTPUT

	FORECAST 1977	1978	1979	1980	1981	1982	1983	1984	1986	1990	1995	2000	2005
ECONOMIC INDICATORS													
GROSS DOMESTIC PROVINCIAL PRODUCT(MILLIONS OF 1976$)	14884.	15449.	16037.	16546.	17270.	17935.	18616.	19324.	20820.	24030.	28129.	32927.	38544.
GDPP-MANUFACTURING(MILS 1976$)	4457.	4610.	4767.	4931.	5099.	5274.	5454.	5640.	6033.	6855.	7839.	8965.	10252.
GDPP-AGRICULTURE(MILS 1976$)	230.	234.	238.	241.	245.	249.	252.	256.	264.	280.	293.	318.	339.
POPULATION(THOUSANDS)	1805.	1830.	1855.	1880.	1906.	1932.	1959.	1985.	2040.	2150.	2279.	2417.	2562.
GDPP-$/CAPITA (1976$)	8244.	8442.	8645.	8352.	9065.	9282.	9505.	9733.	10206.	11177.	12341.	13625.	15043.
TOTAL EMPLOYMENT(THOUSANDS)	735.	753.	771.	790.	810.	830.	850.	871.	914.	1030.	1085.	1177.	1277.
EMPLOYMENT-SERVICE SECTOR(000)	477.	493.	509.	526.	543.	561.	579.	598.	638.	721.	819.	931.	1058.
HOUSEHOLDS(THOUSANDS)	567.	581.	595.	609.	624.	640.	656.	672.	705.	773.	848.	931.	1022.
INDUSTRIAL PRODUCTION													
ALUMINUM (000 TONS)													
WOOD PULP (000 TONS)	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
CHEMICALS (MILS $ OF SHIP)	312.1	326.2	340.9	356.2	372.2	389.0	406.5	424.8	463.9	547.9	650.7	772.8	917.9
STEEL (000 NET TONS)	19.	19.	20.	20.	21.	21.	22.	23.	24.	27.	31.	35.	39.
MINING													
IRON ORE (000 TONS)	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
COPPER (000 TONS)	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
COAL (000 TONS)													
OTHER (000 TONS)	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
TOTAL MINING ACTIVITY-000 TONS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

APPENDIX B

NORTHEAST POWER COORDINATING COUNCIL
1250 BROADWAY/NEW YORK, N.Y. 10001 TELEPHONE 212/868-1400

BASIC CRITERIA FOR DESIGN AND OPERATION OF INTERCONNECTED POWER SYSTEMS

Originally adopted by the members
of the Northeast Power Coordinating
Council, September 20, 1967. Revision
adopted by the members of the Northeast
Power Coordinating Council, July 31, 1970.
Revision adopted by the members of the
Northeast Power Coordinating Council,
June 6, 1975.

CONTENTS

		PAGE
1.	INTRODUCTION	1
2.	GENERATING CAPACITY	2
3.	AREA TRANSMISSION REQUIREMENTS	3
	3.1 Stability Conditions	3
	3.2 Steady State Conditions	4
4.	TRANSMISSION TRANSFER CAPABILITIES	4
	4.1 Normal Transfers	5
	4.1.1 Stability Conditions	5
	4.1.2 Steady State Conditions	6
	4.2 Emergency Transfers	6
	4.2.1 Stability Conditions	6
	4.2.2 Steady State Conditions	6
5.	POSSIBLE BUT IMPROBABLE CONTINGENCIES	7
	APPENDIX - LIST OF DEFINITIONS	8

1. INTRODUCTION

The purpose of the Northeast Power Coordinating Council is to improve the reliability and efficiency of the interconnected power systems of its members through improved coordination in system design and operating procedures.

One of the steps in reaching this objective is the development of criteria that will be used in the design and operation of the major interconnected power systems. Definitions of several terms used in the following paragraphs are listed in the Appendix.

It is recognized that more rigid criteria will be applied in some segments of the Council area because of local considerations. It is also recognized that the basic criteria are not necessarily applicable to those elements of the individual members' systems that are not a major part of the interconnected transmission network.

The transmission criteria are applicable either to the areas (New Brunswick, New England, New York or Ontario) or to the entire Council interconnection in its relations with neighboring "pools".

An interconnected power system should be designed and operated at a level of reliability such that the loss of a major portion of the system would not result from reasonably foreseeable contingencies. In determining this reliability, it would be desirable to give consideration to all combinations of contingencies occurring more frequently than once in some stipulated number of years. However, sufficient data and techniques

are not available at the present time to define all the contingencies that could occur or to assess and rank their probability of occurrence. Therefore, it is proposed that the interconnected power systems be designed and operated to meet certain specific contingencies. Loss of small portions of the system (such as radial portions) may be tolerated, provided that these do not jeopardize the integrity of the over-all interconnected power systems.

The following criteria for design and operation of interconnected power systems define area generation and transmission requirements. In addition, criteria for determining inter-area transmission transfer capabilities are defined.

Two categories of transmission transfer capabilities are to be considered: normal and emergency. Normal conditions are to be assumed unless an emergency, as defined by Item 2 in the "List of Definitions", exists.

Design studies will assume applicable contractual transfers and the most severe expected load and generation conditions. Operating transfer capability studies will be based on the particular load and generation pattern expected to exist for the period under study. All reclosing facilities will be assumed in service unless it is known that such facilities have been rendered inoperative.

2. GENERATING CAPACITY

Generating capacity will be installed and located in such a manner that after the due allowance for required maintenance and expected forced outages, each area's generating supply will equal or exceed area load at least 99.9615 percent of the time. This is equivalent to a "loss-of-load probability of one day in ten years".

3. AREA TRANSMISSION REQUIREMENTS

The power system should be designed with sufficient transmission capacity to serve area loads under the conditions noted below. The power system should also be operated in such a manner that the design objectives are fulfilled.

3.1 Stability Conditions

Stability of the interconnected power systems shall be maintained during and after the most severe of the conditions stated in a, b, c, d, and e below. Also, the system must be adequate for testing of the outaged element as described in "a" through "e" by manual reclosing after the outage and before adjusting any generation. These requirements will also apply after any critical generator unit, transmission circuit, or transformer has already been lost, assuming that the area generation and power flows are adjusted between outages by use of Five-Minute Reserve.

a. A permanent three phase fault on any generator, transmission circuit, transformer or bus section, cleared in normal time, with due regard to reclosing facilities.

b. Simultaneous permanent phase to ground faults on different phases of each of two adjacent transmission circuits on a multiple transmission circuit tower, cleared in normal time, with due regard to reclosing facilities.

c. A permanent phase to ground fault on any generator, transmission circuit, transformer,

or bus section with delayed clearing and with due regard to reclosing facilities. This delayed clearing could be due to circuit breaker, relay system or signal channel malfunction.

d. Loss of any element without a fault.

e. A permanent phase to ground fault on a circuit breaker, cleared in normal time, and with due regard to reclosing facilities.

3.2 Steady State Conditions

a. Voltages, line and equipment loadings shall be within normal limits for pre-disturbance conditions.

b. Voltages, line and equipment loadings shall be be within applicable emergency limits for the system load and generation conditions that exist following the disturbance specified in 3.1.

4. TRANSMISSION CAPABILITIES

Transfers of power from one area to another, as well as within areas, should be considered in the design of inter-area transmission and internal area facilities.

Operating capabilities shall be adhered to for normal transfers and transfers during emergencies. These capabilities will be based on the facilities in service at the time of the transfers. In determining the emergency transfer capabilities, it is assumed that a less conservative margin is justified.

Transmission transfer capabilities shall be determined under the following conditions:

4.1 Normal Transfers

4.1.1 Stability Conditions

Stability of the interconnected power systems shall be maintained during and after the most severe of the conditions stated in a, b, c, d, and e below. Also, the system must be adequate for testing of the outaged element as described in "a" through "e" by manual reclosing after the outage and before adjusting any generation.

a. A permanent three phase fault on any generator, transmission circuit, transformer, or bus section, cleared in normal time, with due regard to reclosing facilities.

b. Simultaneous permanent phase to ground faults on different phases of each of two adjacent transmission circuits on a multiple transmission circuit tower, cleared in normal time, with due regard to reclosing facilities.

c. A permanent phase to ground fault on any generator, transmission circuit, transformer, or bus section with delayed clearing and with due regard to reclosing facilities. This delayed clearing could be due to circuit breaker, relay system or signal channel malfunction.

d. Loss of any element without a fault.

e. A permanent phase to ground fault on a circuit breaker, cleared in normal time, and with due regard to reclosing facilities.

4.1.2 Steady State Conditions

a. For the facilities in service during the transfer, voltages, line and equipment loadings shall be within normal limits.

b. Voltages, line and equipment loadings shall be within applicable emergency limits for the system load and generation conditions that exist following the disturbance specified in 4.1.1.

4.2 Emergency Transfers

4.2.1 Stability Conditions

Stability of the interconnected systems shall be maintained during and after the most severe conditions in "a" and "b" below. System conditions may be adjusted before the outaged element as described in "a" and "b" below is tested.

a. A permanent three phase fault on any generator, transmission circuit, transformer, or bus section, cleared in normal time and with due regard to reclosing facilities.

b. Loss of any element without a fault.

4.2.2 Steady State Conditions

a. For the facilities in service during the transfer, voltages, line and equipment loadings shall be within applicable emergency limits.

b. Voltages, line and equipment loadings shall

be within applicable emergency limits following the disturbance in 4.2.1.

5. POSSIBLE BUT IMPROBABLE CONTINGENCIES

Studies will be conducted to determine the effect of the following contingencies on system performance and plans will be developed to minimize the spread of any interruption that might result.

a. Loss of the entire capability of a generating station.

b. Loss of all lines emanating from a generating station, switching station or substation.

c. Loss of all transmission circuits on a common right-of-way.

d. Permanent three phase fault on any generator, transmission circuit, transformer, or bus section, with delayed clearing and with due regard to reclosing facilities. This delayed clearing could be due to circuit breaker, relay system or signal channel malfunction.

e. The sudden dropping of a large load or major load center.

f. The effect of severe power swings arising from disturbances outside the Council's interconnected systems.

APPENDIX - LIST OF DEFINITIONS

1. AREA

An area is defined as either New Brunswick, New England, New York or Ontario.

2. EMERGENCY

An emergency is assumed to exist in an area if firm load may have to be dropped because sufficient power is unavailable in that area. Emergency transfers are applicable under such conditions.

3. APPLICABLE EMERGENCY LIMITS

These limits depend on the duration of the occurrence, and on the policy of the various member systems of NPCC regarding loss of life to equipment, voltage limitation, etc.

Short time emergency limits are those which can be utilized for at least five minutes.

The limiting condition for voltages should recognize that voltages at key locations should not drop below that required for suitable system stability performance, and should not adversely affect the operation of the interconnected systems.

The limiting condition for equipment loadings should be such that cascading will not occur due to operation of protective devices on the failure of facilities.

4. FIVE-MINUTE RESERVE

Five-Minute Reserve is that portion of unused generating capacity which is synchronized to the system, and is fully available within five minutes, plus that portion of capacity available in shut down generating units, in pumpeu hydro units and by curtailing interruptible loads which is fully available within five minutes.

5. "WITH DUE REGARD TO RECLOSING FACILITIES" is intended to mean that recognition will be given to the type of reclosing: i.e., manual or automatic, and the kind of protective schemes insofar as time is concerned.

6. ELEMENT

An element is defined as a generator, transmission circuit, transformer, circuit breaker or bus section.

APPENDIX C

Date February 10, 1975

System Planning Division

Guides for Planning Area and Regional Supply Facilities

1. Introduction

System Planning Division Procedure No. E1 "Guides for Planning the Main Trunk Transmission System" specifies the reliability requirements for design of the power system. While those criteria apply mainly to the bulk power system where contingencies are more likely to cause loss of a major portion of the East System or jeopardize the interconnected system, they also apply to other parts of the power system where local instability from a fault could cascade into the bulk power system. Studies to check the adequacy of all parts of the system to meet those criteria are normally carried out by those who plan the bulk-power system.

In addition to designing the system as a whole for adequate stability and steady-state operation, it is necessary to design each part of the system for adequate continuity or availability of supply to individual large customers and to transformer stations supplying the distribution system. Criteria for availability are therefore required, particularly for the parts of the system known as Area and Regional Supply Facilities. Such criteria are contained in this Procedure E2.

It is also necessary to provide facilities for maintaining adequate normal and emergency voltages throughout the system. Voltage control is achieved mainly by installation of reactive power sources throughout the system, from generators to distribution capacitors. Voltage criteria will be covered by a separate procedure.

This Procedure E2 is not intended as a set of rigid rules, but rather as a guide towards establishing the minimum availability criteria for the Area and Regional Supply system. Parts of the system may be designed for lower availability, but this should only be done where the stage is temporary, where the reliability requirements of the load are low, or where the cost of the recommended reliability is unjustifiably high. Occasionally a higher availability may be justified, where the load is unusually sensitive or the cost of improvement is low.

Copies of this Procedure are being sent to the Power System Operations Division, with a note emphasizing that it is being used as a guide only, and hence will not be rigidly applied.

Because this Procedure is based primarily on the accumulated experience of the members of System Planning Division, it will be revised as considered necessary. Section Heads and Planning Engineers are asked to use this procedure now on a trial basis and to report any comments or suggestions for change to their Department Head.

2. The Area and Regional Supply System

This comprises all 230 kV and 115 kV circuits supplying step-down transformer stations from 230 kV or 115 kV to 44, 27.6 or 13.8 kV (called LV in the following), the step-down stations themselves, and the 500-115, or 230-115 kV autotransformers and associated switching used for area supply. The high-voltage switching at major stations must be considered not only for its effect on area supply, but also for its effect on system stability.

3. Normal Operation

Normal operation is the condition under which all lines, transformation and switching in the location being studied are in-service. Under these conditions all facilities are to be loaded within their established normal capabilities, and all voltages are to be within their normal range for any condition of load or generation which could reasonably be expected to occur at any time of the year.

4. Emergency Operation

Emergency operation is the condition under which one or more elements of the system are out of service for routine maintenance, or for repair because of a failure. A number of common emergency conditions are listed in Table I. The operating conditions applying during the emergency are determined by the availability level assigned for a particular emergency and a particular size of load. These availability levels are defined in Section 6 below.

In all availability levels except C, it is permissible for the load to be interrupted, but the load must be restored to service within the specified period, depending on the availability level.

At all times during the emergency while load is being supplied, all facilities are to be loaded within their applicable emergency capabilities. This may be either short-term or long-term emergency capability as conditions dictate.

5. <u>Load Level</u>

The availability level required depends on the size of the load. For purposes of Table I, the load level is the peak load in Megawatts for the most critical month for the station or group of stations being studied, for a time about 2 to 5 years hence, depending on the lead-time for the new facilities. It is the load which would be interrupted by the occurrence of the contingency listed. Where "Interruptible" load is supplied from a station, the level of availability required should be discussed with Customer Service Division.

6. <u>Availability Levels</u>

C Continuous supply. This is the highest level. There should be no interruption in supply as a result of the occurrence of the contingency. This level is designated C in Table I.

The voltage may collapse for a few cycles while a fault is being cleared but it must rise immediately after fault clearance, and must be restorable to an acceptable emergency level by automatic action such as on-load tap changers. Transfer of such load to another source is permissible to relieve overload, but the transfer must be done without interrupting the load.

RR Restorable Rapidly. An interruption of 2 seconds is permissible at the time of a contingency or at the later time of load transfer. Restoration within 2 seconds must be accomplished automatically by operation of LV breakers without operator intervention.

RS Restorable by Switching. Load may be interrupted at the time of the contingency, but it must be restorable within one-half hour, for example by the action of a control-room operator using remote or supervisory control, or by use of automatically operated switching at the affected station.

R2 Restorable by Manual Switching. Load may be interrupted at the time of the contingency, but it must be restorable within 2 hours. It is assumed there will be switches, quick-openers or other devices available, which can be operated by a travelling operator or maintenance man to restore service. Means of quickly transferring metering, and relaying will also be required.

R8 Restorable by Maintenance. Load may be interrupted at the time of the contingency, and restoration must be within 8 hours. Restoration is assumed to be the result of repair work or temporary connections which can be made by a maintenance crew. This may comprise such line work as replacement of a pole, crossarm, or insulators, repair of a broken conductor, by-passing a defective switch, or such station work as repair or replacement of a defective low-voltage breaker, connecting of an on-site spare transformer (including metering, relaying, and service supply). Station design must be suitable for transformer connection to be accomplished within 8 hours.

X There is no fixed standard of availability against contingencies marked X. These are treated as "Possible but Improbable Contingencies". Each case must be considered separately, taking into account the probability of occurrence, length of repair time, extent of hardship caused, and cost of providing availability against the contingency. In any specific case the availability will be at a level no higher than R8, and may be as low as to permit the outage to extend for several days.

7. Requirements for Transferring Load

The action to restore supply may be taken either at the location where the fault occurred, thus restoring supply along the normal supply path, or at a remote location to transfer the load to another source. If load is transferred, provision must also be made to transfer it back to the normal supply at a convenient time with minimum interruption.

In the case of transformers and some cables, which have a high short-term overload capability, advantage may be taken of this capacity, provided excess load can be transferred off within the time limit set by the short-term capability.

8. Possible but Improbable Contingencies

No standards are set for availability against more severe contingencies than those listed in Table I because of their low probability of occurrence and the generally very high cost of reliability measures. However, consideration should be given to the effect of these contingencies on specific important loads, and the availability against them should be improved wherever this can be done at reasonable cost.

Some catastrophic contingencies for which there is no minimum standard are:

- Loss of several towers due to windstorm or vehicle impact.
- Simultaneous or overlapping outage of two independent elements, such as outage of a transformer and the line supplying a second transformer at the same station.
- Fire or explosion following a fault.
- Loss of all circuits on the same right of way.
- Loss of a complete station.

Another group of contingencies which can occur, but which are only affected to a limited extent by planning decisions are listed below.

- Errors in design, construction, or operation.
- Failure or misoperation of relaying.
- Failure of supervisory control.
- Faults in station service system.

One type of possible but improbable contingency which will need more consideration in future is the catastrophic outage of several circuits on one right of way. It is likely that in the medium term future there will be narrow rights of way containing heavily-loaded multi-circuit tower lines

with close spacing between lines and shared use of the right of way. In such cases, there is risk of an extended outage to one or more towers of one or more lines due to causes such as:

- Tornadoes
- impact by aircraft
- gas-line explosion
- relocations for highway modifications
- footing damage due to flooding or land slippage.

In the past, it was possible to provide a temporary woodpole bypass circuit on short notice, but such will not be possible on a crowded right of way. Therefore, consideration will have to be given to provision of back-up circuits from a different direction so that part of the load can be restored while repair to the damaged section is carried out. The criteria of Table I require provision of backup to large loads for loss of two circuits, but this backup need not be from a different direction, and can, in fact be from two other circuits of the same multicircuit line.

H.P. Smith

H.P. Smith
Director of System Planning

February 10, 1975

TABLE I

AREA AND REGIONAL SUPPLY MINIMUM AVAILABILITY LEVELS

TYPE OF FAULT OR OUTAGE	Load Level of Station or Group Affected By Fault Or Outage (Megawatts)						
	1 To 15	16 To 40	41 To 75	76 To 150	151 To 250	251 To 500	501 And MORE
Transformer	R8	R2*	RS**	RS	RR	C	C
Overhead Circuit	R8	R8	R8	RS	RR	C	C
Cable Circuit	X	X	R8	RS	RR	C	C
Bus	R8	R2*	R2	R2	R2	C	C
Breaker	R8	R8	R2	R2	R2	R2	R2
Maintain an Element	Same as For Fault						
Two Transformers	X	X	X	X	X	X	X
Double-Circuit Line (Non-Catastrophic)	R8	R8	R8	R8	R8	RS	C
" " " (Catastrophic)	X	X	X	X	X	RS	C
2 ccts of Multicircuit Line	R8	R8	R8	R8	R8	RS	C
Multicircuit Line (Catastrohpic)	X	X	X	X	X	X	X
Two Cables in Same Trench	X	X	X	X	RS	RS	RS
Two Cables Different Trenches	X	X	X	X	X	X	RS
Two Breakers	R8	R8	R8	R8	R8	R8	R2

* Up to 15 MW can be R8
** " " 40 " " " R2

C - Continuous
RR - Restorable Rapidly (LV switching in 2 sec)
RS - Restorable by Switching (30 Min)
R2 - Restorable in 2 Hours by Travelling Operator
R8 - Restorable in 8 Hours by Maintenance Crews
X - No Special Provision

APPENDIX D

ANNUAL FREQUENCY AND DURATION OF OUTAGES

Type of Forced Outage	Average No of Incidents Due to Problem with:			Average No of Incidents/year Having Duration of:			Average of Durations Lasting Over 5 Minutes	Maximum Duration
	Line	Protection	Total	Less than 1 Minute	1 to 5 Minutes	Over 5 Minutes	Hours	Hours
					Circuit D4W			
Automatic	1.1	1.1	2.3	1.0	1.0	0.3	9.7	19.0
Manual	0.5	0.4	0.9	-	0.1	0.8	1.8	2.8
					Circuit D5W			
Automatic	1.0	1.5	2.5	1.5	.6	.4	0.3	0.5
Manual	.3	.8	1.0	-	-	1.0	4.1	19.0
					Circuit D6V			
Automatic	1.0	1.2	2.2	1.2	0.5	0.4	81.3	238.3
Manual	0.3	0.3	0.6	-	-	0.6	2.3	3.9
					Circuit D7V			
Automatic	1.4	0.6	2.0	0.7	0.6	0.7	40.7	238.3
Manual	0.3	0.6	0.8	-	-	0.8	1.6	4.2
					Circuit M20D			
Automatic	2.6	0.7	3.4	2.4	1.0	-	-	-
Manual	1.2	0.2	1.4	-	2.4	1.2	5.3	12.3
					Circuit M21D			
Automatic	0.2	0.5	0.7	-	0.5	0.2	0.4	0.4
Manual	1.7	0.7	2.4	-	-	2.4	6.6	8.8

ANNUAL FREQUENCY AND DURATION OF OUTAGES

Type of Forced Outage	Average No of Incidents Due to Problem with:			Average No of Incidents/year Having Duration of:			Average of Durations Lasting Over 5 Minutes	Maximum Duration
	Line	Protection	Total	Less than 1 Minute	1 to 5 Minutes	Over 5 Minutes	Hours	Hours
				Circuit M31W				
Automatic	0.6	0.6	1.2	0.2	0.2	0.8	1.2	1.7
Manual	0.6	0.2	0.8	-	-	0.8	6.5	10.2
				Circuit M32W				
Automatic	5.4	0.6	5.9	3.9	0.9	1.1	44.5	266.2
Manual	0.2	0.4	0.6	-	-	0.6	2.9	8.2
				Circuit M33W				
Automatic	7.5	0.5	8.0	5.6	1.3	1.3	11.2	78.8
Manual	0.2	0.4	0.5	-	-	0.5	0.7	1.5

CIRCUIT LENGTHS &
YEARS OF RECORD FOR
CRITICAL SOUTHWESTERN ONTARIO CIRCUITS

Circuit	Length (km)	Record (Years)
D4W	89.4	8.000
D5W	89.4	8.000
D6V	64.8	6.833
D7V	64.8	7.083
M20D	72.5	4.167
M21D	72.5	4.167
M31W	96.8	5.167
M32W	96.8	5.417
M33W	96.8	5.583